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ARTIGO ORIGINAL

Preoperative physical activity has a protective effect against postoperative pulmonary complications after abdominal surgery

Atividade física pré-operatória tem efeito protetor contra complicações pulmonares após cirurgia abdominal

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Abstract

Physical activity level and fitness condition seem to be related with pulmonary surgical risk in thoracic and cardiac surgeries; however, in abdominal surgery this relation is not clear. Objective: To compare the physical activity level in daily life and during hospitalization before surgery between patients who developed and did not develop postoperative pulmonary complications (PPC) after abdominal surgery and to relate to this outcome. Methods: This prospective cohort enrolled 191 hospitalized candidates (52 ± 14yrs; BMI = 29 ± 11 kg/m2) for upper abdominal surgery. Two different tools related to two distinct moments were used to assess preoperatively the physical activity level. First, to assess life physical activity level, the questionnaire Human Activity Profile (HAP) was administered for all patients. During hospitalization, the accelerometry was performed during 4 consecutive days to assess the time in activity. In addition, lung function, muscle strength and resting energy expenditure were assessed. PPC (pneumonia, atelectasis or severe hypoxemia) were checked until discharge. Multivariate analyses were used. Results: 92% of patients were classified as moderately to physically active in daily life. During hospitalization, patients were inactive during 90% ± 5% of time. There was no association with HAP score and acelerometry. 10.5% of patients developed PPC. Being physically active in daily life and during hospitalization have a protective effect against PPC. Our results show that the physical activity behavior in hospital do not reflect the daily life even in patients not restricted to bed and on preoperative period, patients physically actives on daily life and during hospitalization present less chance to develop PPC after abdominal surgery.
Keywords: surgery, physical activity, postoperative complication, pneumonia, accelerometry, hospitalization.

Resumo

O nível de atividade física e o condicionamento físico parecem estar relacionados ao risco cirúrgico pulmonar em cirurgias torácicas e cardíacas; no entanto, na cirurgia abdominal, essa

relação não é clara. Objetivo: Comparar o nível de atividade física na vida diária e durante a hospitalização antes da cirurgia entre pacientes que desenvolveram e que não desenvolveram complicações pulmonares pós-operatórias (CPP) após cirurgia abdominal e relacionar esses desfechos. Métodos: Esta coorte prospectiva recrutou 191 pacientes hospitalizados não restritos ao leito e candidatos a cirurgia abdominal (52 ± 14 anos; IMC = 29 ± 11 kg/m^2; VEF1 = 98 ± 19% do predito; CVF = 96 ± 16% do predito). Duas ferramentas diferentes relacionadas a dois momentos distintos foram utilizadas para avaliar o nível no pré-operatório de atividade física. Primeiro, para avaliar o nível de atividade física da vida diária, o questionário Perfil de Atividade Humana (PAH) foi aplicado a todos os pacientes. O PAH possui 94 perguntas sobre a execução de atividades gradualmente mais intensas. O PAH classifica o paciente como inativo (<54 pontos), moderadamente ativo (54 a 73 pontos) e ativo (>73 pontos). Segundo, a acelerometria foi realizada durante 4 dias consecutivos para avaliar o tempo de atividade durante a hospitalização. As CPP (pneumonia, atelectasia ou hipoxemia grave) foram verificadas até a alta. Análises multivariadas foram utilizadas. Resultados: 92% dos pacientes foram classificados como moderados a fisicamente ativos na vida diária. Durante a hospitalização, os pacientes ficaram inativos em 90% ± 5% do tempo. Não houve associação com escore do PAH e acelerometria. Cerca de 10,5% dos pacientes desenvolveram CPP. Ser fisicamente ativo na vida diária e durante a hospitalização tem um efeito protetor contra CPP (Odds ratio [OR] = 0,69, IC 95% 0,01-0,93; OR=0,61, IC 95% 0,12-0,87, respectivamente). Nossos resultados mostram que o comportamento da atividade física no hospital não reflete o da vida diária, mesmo em pacientes não restritos ao leito e no período pré-operatório, e os pacientes ativos fisicamente na vida diária e durante a internação apresentam menor chance de desenvolver CPP após cirurgia abdominal.
Palavras-chave: cirurgia, atividade física, complicação pós-operatória, pneumonia, acelerometria, hospitalização.

Introduction

Postoperative pulmonary complications (PPC) are frequent after major surgeries [1] and increase the morbidity and mortality risks and the length of hospital stay [2]. Clinical and surgical aspects are involved in the risk of development of PPC as chronic respiratory diseases, aged and obesity [3]. Recently, the poor exercise tolerance has been also considerate as a risk factor for developing of postoperative complications after cardiothoracic [4,5] and non-cardiothoracic surgeries [6,7]. Probable, the relation between the exercise tolerance and development of PPC is associated with physiologic reserve and the capacity of recovery after a large trauma expected in major surgeries [4].

The patients' exercise tolerance reflects the daily life physical activity behavior [8]. Patients with poor exercise tolerance, especially those with chronic respiratory diseases, frequent present the harms from a sedentary lifestyle as the early development of other chronic diseases, obesity, deficit of oxygen transport and impaired functionality [9]. In surgical population, Cook et al. observed that patients with poor exercise tolerance had presented higher risk for complications and longer length of hospital stay after cardiac surgery [10]. On the other hand, some studies have showed that preoperative physical activities programs for vulnerable patients (older, oncologic, abnormal lung function and with cardiac diseases) seems to improve their functional status before surgery and accelerate their functional recovery and hospital discharge after surgery) [11,12]. However, the evidences that physical activity programs decrease the incidence of PPC after major surgeries stills weak [11,12].

Considering that the preoperative hospitalization for finish the exams and preparation for surgery increases the time in inactivity impairing the muscle strength [13], the nutritional status [14] and the functionality [13] and that these are factors associated with PPC [14], it is possible to admit the hypothesis that physical activity behavior before and during hospitalization can be related with PPC.

Objective

To compare the physical activity level in daily life and during hospitalization before surgery between patients who developed and who did not develop PPC after abdominal surgery and to relate to this outcome.

Methods

Design

Two hundred twelve consecutive candidates for elective abdominal surgery were enrolled for this prospective cohort study in a University hospital. The exclusion criteria adopted were: restriction to bed, refuse to wear the accelerometer over 4 days, hospital discharge before surgery, undergoing mechanical ventilation longer than 48h after surgery and reoperation. The Ethics Committee of the Clinics Hospital, University of São Paulo approved this protocol study (CAAE: 06324412.9.0000.0068).

Setting

Hospital of Clinics, School of Medicine, University of Sao Paulo, Sao Paulo, Brazil

Experimental design

All eligible candidates for surgery were invited to participate of this study. After they had signed the consent forms, the patients were assessed for anthropometric characteristics, medical history, serum albumin level, lung function, muscle strength, resting energy expenditure, the physical activity level on daily life and during hospitalization before surgery. After surgery, all patients received standard medical and physiotherapist care and they were followed for PPC recorder until the hospital discharge.

Assessments

Clinical history: data about comorbidities, smoking and drinking habits were collected.

Serum albumin level: was collected at baseline. The critical level for poor nutritional status was set at 3.5 dl/g [15].

Lung function: Spirometry (Spirobank II, MIR, Italy) was performed according to the guidelines [16]. The relative values were expressed in the percentage of prediction for Brazilian normality [17]. The following variables were considerate: forced vital capacity (FVC), forced expiratory volume in the first second (FEV1).

Respiratory muscle strength: Maximal inspiratory pressure and maximal expiratory pressure indicate the muscle respiratory strength and were measured as previously described (M120, GlobalMed, Brazil) [18]. The best value from three acceptable maneuvers (variation <10%) was recorded.

Peripheral muscle strength: Skeletal muscle strength of the dominant hand was measured by a dynamometer (Crown Manual, Filizola, Brazil), with patient in sit position and elbow flexed at 90 degrees. The best value from three acceptable maneuvers (variation <10%) was recorded.

Resting energy expenditure: This variable was assessed by indirect-calorimetry (Metacheck, Korr, USA) and reflect the basal metabolic rate. All patients had fasted for four hours and stayed lying down during the measurement at rest. The gas analyzer was connected to the patient by a mask and was calibrated following recommendation of the manufacturer before each test. The amounts of oxygen and carbon dioxide were collected breath by breath by the calorimeter for 10 minutes with the patient lying supine. The equipment uses the Harris-Benedict equation to calculate the estimate of calories spend for 24 hours [19].

Physical activity level: Assessed referring for two distinct moments.

On daily life: was assessed via Human Profile Activity (HAP). It is a questionnaire containing 94 items that measures the energy expended in daily activities and fitness [20]. The questions do not address a specific point in time, and the patient responses concerning the opportunity / chance to perform a given activity are that he / she is able to do it, is no longer able to do it or never did it. The overall score constantly increases and ranges from 0 to 94 [21]. The adjusted score was used, given by the more intense activity that the patient still engages in subtracted from the number of activities he / she stopped performing. Activities never performed were not considered in the final score [20]. The classification of the physical activity level is determined as low (inactive) if the score is less than or equal to 53 points, moderate (moderately active) if the score is between 54 and 73 points and high (active) for a score of 74 points or more [21].

During hospitalization: was assessed via accelerometer (Actigraph GTX3, Actigraph, USA) installed on the patient's waist using a stretchable elastic band and maintained for four consecutive days, as recommended by the manufacturer, starting until 24 hour after admission. The device is waterproof and therefore the patient does not need to remove it at any time. The device measures the acceleration in three orthogonal planes (vertical, medial-lateral and antero-posterior) and is separately valid for each of the three axes of acceleration [22]. After the results of the activities are captured, the software can infer the caloric expenditure during the performance of daily living activities of the patients monitored [22]. In addition, the accelerometer quantifies the time that the patient spends at each level of physical activity. Inactivity, which is the expected predominant level of physical activity among hospitalized patients, is determined as zero to 199 movements per minute [22]. The mean values of the four sampling days were used.

Postoperative pulmonary complications: The following PPC were considered: atelectasis with clinical consequences [23], hypoxemia with oxygen saturation <85% and need of supplemental O2 [24] and pneumonia [25]. A physician who was blinded to preoperative assessment results performed the diagnosis of PPC. If any complication was diagnosed, the patient received the proper treatment according to the clinical criteria.

Statistical analysis

Sample size was calculated considering a difference of 10% on incidence of PPC in active and inactive patients, power of 0.80 and $p<0.05$ [2]. A sample of 107 patients would be necessary.

Data underwent descriptive analyses. The normality was tested by Kolmogorov-Smirnov. Spearman's correlation was used to test association between HAP adjusted score and variables from accelerometry as well as calorimetry and variables from muscle strength and HAP points. T test, Mann-Whitney and chi-square tests were used to compare the groups with and without PPC, depending on data distribution. Models of multiple logistic regression analysis were tested for predicting PPC using as independent variables: age, BMI, presence of comorbidity (yes or not), presence of cancer (yes or not), smoker (yes or not), alcoholic (yes or not), serum albumin, points on HAP, scoring as inactivity or active on HAP, percentage of time in activity or in inactivity during hospitalization and muscle strength. Univariate analysis were performed to calculate odds ratio. The level of significance was set at 5%. The software SigmaPlot 12.1 (San Jose, USA) was used.

Results

Of 212 patients assessed at baseline, 191 underwent surgery and 21 were excluded (15 for cancelled surgeries and 6 for clinical complications before surgery). All presented data are from 191 patients who complete the study. The demographic, anthropometric, lung function, clinical characteristics and muscle strength of 191 patients assessed are in Table I.

The physical activity level in daily life and during hospitalization of candidates for surgery are in Table II. On daily life, 92% patients were considerate moderately to physically actives. During hospitalization, patients spent 10.4% of total time being actives independent of the intensity of the activity (Table II).

There was no correlation between points obtained from HAP questionnaire relative to daily life and variables from accelerometer during hospitalization on preoperative period ($p>0.05$) (Table III).

There was positive correlation between resting energy expenditure assessed indirect calorimetry and daily life physical activity level obtained from HAP questionnaire and muscle strength assessed in the first 24h after hospitalization, on preoperative period (Table IV).

The average of surgical duration was 282.50 ± 92.72 minutes and 46% (n=88) of surgeries was via laparoscopic. The procedure carried out were: 42 (22%) rectosigmoidectomy/colectomy, 40 (21%) gastrectomy, 29 (15%) bariatric surgery, 25 (13%) esophagectomy, 24 (13%) cholecystectomy, 15 (8%) hiatoplasty, 13 (7%) hepatectomy and 3 (2%) pancreatectomy.

After surgery, the incidence of pulmonary complications was 10.5% (n=20), being 18 pneumonia and 2 atelectasis with clinical repercussion. Observing the group that developed PPC, they had higher age, number of smokers and alcoholics, ASA score classification and surgical duration as well as lower predict value of FEV1 than the group that did not developed PPC (Table V). We did not observe difference in physical activity level before and during hospitalization or in muscle strength (Table V) between groups.

In regression models, age and being alcoholic were independent predictor factor for PPC (R2 = 0.30). On the other hand, the physical activity in daily life (assessed by HAP questionnaire) (Odds ratio = 0.69, 95% IC 0.01 to 0.93) and the percentage of time in activity, independent of the intensity of the activity, during hospitalization (Odds ratio = 0.61, 95% IC 0.12 to 0.87) had a protective effect against postoperative pulmonary complications, as demonstrated in follow equation:

PPC=3.194 - (3.335 * % of time in activity) - (1.878* physically active by HAP)

Table I - *Characteristics of assessed patients (n = 191).*

Variables	Median (IQR 25% - 75%)
Age, years	52.00 (42.00 – 62.50)
Weight, kg	78.00 (61.50 – 100.00)
Height, m	1.63 (1.57 – 1.70)
BMI, kg/m^2	28.96 (23.54 – 39.14)
Albumin, dl/g	3.53 (3.25 – 3.70)
FEV_1, % of predict	98.00 (91.50 – 104.50)
FVC, % of predict	95.50 (88.00 – 102.50)
	Frequency
Sex M, n (%)	98 (46%)
Cancer, n (%)	83 (39%)
Comorbidities, n (%)	117 (55%)
ASH, n (%)	87 (46%)
DM, n (%)	29 (15%)
COPD or Asthma, n (%)	6 (12%)
Others, n (%)	9 (15%)
Smoker, n (%)	28 (13%)
Alcoholic, n (%)	6 (3%)
	Median (IQR 25% - 75%)
Maximal inspiratory pressure, cmH_2O	80.00 (65.00 – 115.00)
Maximal expiratory pressure, cmH_2O	80.00 (75.00 – 100.00)
Peripheral muscle strength, Kgf	30.00 (25.00 – 40.00)
Resting energy expenditure, kcal	1445.00 (1300.75 – 1685.00)

Data are presented as median (IQR=interquartile range 25% – 75%) and frequency. BMI=body mass index; M=male; n=absolute number FEV1=forced expiratory volume in the 1st. second; FVC=forced vital capacity; % of predict for Brazilian population16; ASH = arterial systemic hypertension; DM=diabetes mellitus; COPD=chronic obstructive pulmonary disease; cmH2O=centimeter of water; Kgf=kilogram force; kcal=kilocalorie.

Table II - *Physical activity behaviour (n=191).*

Daily life	Values
Inactive by HAP score, n (%)	17 (8%)
Moderately active by HAP score, n (%)	134 (63%)
Active by HAP score, n (%)	61 (29%)
HAP, points	67.00 (62.00 – 75.00)
During hospitalization	
Spent calories	145.26 (95.55 – 250.19)
MET	1.03 (1.02 – 1.06)
Step count	2298.5 (1624.67 – 2972.50)
Time in inactivity, %	89.60 (84.70 – 92.50)
Time in light activity, %	7.25 (5.31 – 10.50)
Time in life style activity, %	2.16 (1.45 – 3.07)
Time in moderate activity, %	0.72 (0.50 – 1.25)
Time in vigorous activity, %	0.02 (0.00 – 0.00)

Data are presented in median (IQR=interquartile range 25% – 75%) and in frequency. Physical activity behavior during hospitalization was assessed by accelerometry before surgery. HAP=Human Activity Profile; MET=metabolic equivalent; %=percentage of total time of accelerometry.

Table III - *Correlation between physical activity in daily life and during hospitalization (n=191).*

		Spent calories	MET	inactivity	light activity	life style	moderate activity	vigorous activity	Step count
HAP points	r	-0.1	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0
	p	0.31	0.71	0.61	0.53	0.71	1.00	0.19	0.88

HAP = Human Activity Profile points from adjusted score; r = correlation factor; MET = metabolic equivalent.

Table IV - *Correlation among resting energy expenditure, daily life physical activity level and muscle strength (n=191).*

		HAP points	Maximal inspiratory pressure	Maximal expiratory pressure	Peripheral strength
Energy expenditure	r=	0.58	0.43	0.34	0.53
	p=	<0.001	<0.001	<0.001	<0.001

HAP=Human Activity Profile points from adjusted score; r=correlation factor. p value from Spearman's correlation test.

Table V - *Comparison between patients with and without PPC after elective abdominal surgery (n = 191).*

	With PPC (n=20)	Without PPC (n=171)	P
Age, years	63.73 ± 12.27*	50.42 ± 13.93	0.003
BMI, kg/m²	26.84 (23.89 – 33,09)	29.22 (23.51 – 39,23)	0.71
Male, n (%)	9 (45)	77 (45)	0.75
Comorbidities, n (%)	16 (82)	90 (53)	0.12
Cancer, n (%)	7 (36)	65 (38)	0.86
Smokers, n (%)	9 (45)*	17 (10)	0.005
Alcoholic, n (%)	5 (25)*	0 (0)	<0.001
Albumin, dL/g	3.44 (3.25 – 3.67)	3.56 (3.40 – 3.72)	0.08
FVC, % of predict	90.0 (83.0 – 96.0)	96.0 (89.0 – 103.0)	0.14
FEV_1, % of predict	88.0 (85.20 – 97.5)*	98.0 (92.0 – 105.00)	0.03
ASA, score	2.1 ± 1.1*	1.7 ± 0.6	0.04
HAP, points	64.82 ± 7.96	68.09 ± 9.94	0.29
Active, HAP score	18 (91)	157 (92)	0.65
Step count	2334.33 (1715.83 – 2706.50)	2271.67 (1626.67 – 3099.58)	0.70
Time in inactivity, %	89.20 (86.00 – 89.90)	90.00 (84.40 – 92.50)	0.66
Time in activity, %	10.80 (10.00 – 14.00)	10.00 (7.00 – 16.00)	0.66
Maximal inspiratory pressure, cmH_2O	70.00 (70.00 – 80.00)	80.00 (60.00 – 120.00)	0.21
Maximal expiratory pressure, cmH_2O	80.00 (80.00 – 100.00)	80.00 (77.50 – 100.00)	0.86
Peripheral muscle strength, Kgf	28.00 (25.25 – 37.50)	32.00 (25.00 – 40.00)	0.41
Resting energy expenditure, kcal	1445.00 (1300.75 – 1685.00)	1535.00 (1357.75 – 1811.00)	0.36
Surgical duration, min	312.30 ± 101.53*	242.15 ± 102.44	0.04

Data are presented as median (IQR=interquartile range 25% – 75%), frequency and mean ± standard deviation. BMI=body mass index; n=absolute number; PPC=postoperative pulmonary complication; FVC=forced vital capacity; FEV1=forced expiratory volume in the 1st. second; ASA=American Society of Anesthesiology Index; cmH2O=centimeter of water; Kgf=kilogram force; min=minutes; kcal=kilocalorie; PPC=postoperative pulmonary complications; p<0.05 value from t test or Mann-Whitney depend on continuous data distribution or chi-square for categorical data.

Discussion

This prospective cohort aimed to verify if the physical activity behavior on daily life and during hospitalization influence the development of PPC. Our results show that being physically active in daily life and during hospitalization on preoperative period have a protective effect against pulmonary complications after elective abdominal surgery. Besides, the patients' daily life physical behavior is not transposed to inside the hospital even on preoperative period of elective surgeries and without bed rest need. In our knowledge, it is the first time that this association is reported.

The most part of assessed patients was classified as moderate to physically active on daily life. This good functional capacity was reflected by the preserved overall muscle strength, basal metabolic rate and nutritional status early hospitalization. Previous studies also observed the great functional capacity of candidates for elective abdominal surgery [2,25], however they could not associate this variable with PPC, probable because all patients presented high performance on applied tests, making it difficult to differentiate patients with and without risk of PPC. Before these previous studies reports, a new tool for surgical risk assessment was chosen, the HAP questionnaire. This questionnaire includes daily life activities ranging from very easy to very strenuous, with good properties of measurement [19], and it has been widely used in healthy and populations with chronic diseases however no in surgical population. The questions involve self-care activities, work, social activities and exercises, and activities that require the use of muscle groups of the hands, legs, trunk and use of wheelchairs [19]. Obviously, the use of an instrument that objectively assess the level of physical activity seems to be more attractive than applying a questionnaire, but, in clinical practice, devices as pedometer or accelerometer are not cheap, requires consecutive days of assessment and at least two visits at hospital or clinics, making it difficult to use for surgical risk assessment out of protocol studies.

Inside the hospital, previously actives patients adopted a sedentary behavior with no correlation with their daily life behavior, and it is related to development of PPC. Our hypothesis is that the hospital structure, the lack of information and the poor stimulus from health care staff are the most important factors related to this change. Previous studies have showed that hospitalization seems to be associated with impairments in functionality, independency and muscle strength [13,26,27], probable because of long time in inactivity [28]. This result from hospitalization could be partially responsible for older, more obstructive, smokers, alcoholic and patients with high surgical risk present more PPC after abdominal surgery [13,28].

The incidence of PPC observed was 10.5% which is similar with the literature [2,14]. Pneumonia was the most frequent complication recorded in our population. Santos et al. observed that when walking is also used to treat patients undergoing thoracic surgery, the rate of pneumonia decreases [29]. The association among postoperative pneumonia and elderly, alcoholics, smokers and low FEV1 was previously descripted. The impairment of muscle strength and immunity capacity age-related is related to loss of cough potency and higher incidences of pneumonia [2,3,14]. The smoking habit increases mucus production, impairs clearing of secretions, leading to sputum retention favoring the development of pneumonia [30]. While, the alcoholic patients showed immunological modifications as increased levels of IL-10, suppression of the IL-6/IL-10 ratio and hypercortisolism immediately after surgery that were associated with a postoperative pneumonia [31,32]. Often, smoking and drink habits are associated with a sedentary behavior [33], so our hypothesis is that these patients developed more PPC because they had unhealthy lifestyles.

The strong points of this study were the use of a simple questionnaire and the accelerometer to assess candidates' physical activity behavior before abdominal surgery. Our results show that patients able to upstairs 50 steps or walking 2 miles into 1 hour or swimming 25 meters (related to 74 points on HAP) have 31% less change of developed PPC after abdominal surgery. In the other hand, if during hospitalization waiting for surgery, the patients were able to walk and do not spend most part of time sitting or lying down, they have 39% less chance to developed PPC. Often, candidates for elective abdominal surgery are not vulnerable patients compared to patients with lung or cardiac diseases, however presented higher incidence of pulmonary complications, and simple orientations from health care staff can be enough to prevent PPC. Other populations, as candidate for thoracic and cardiac surgeries, can need of more advantage preoperative fitness programs for prevent PPC, but it does not seem to be the case of candidates for abdominal surgery.

This study has two important limitations. The impact of hospitalization on muscle strength and this association with development of PPC were not assessed, and the accelerometry was not performed before hospitalization; however, the use of a questionnaire to assess the physical activity level showed to be enough and it can expanding the clinical utility and applicability of our results.

Conclusion

Our results show that the physical activity behavior in hospital does not reflect the daily life even in patients not restricted to bed. However, if patients perform simple activities as to upstairs, to walk or to swing before hospitalization and still physically active during hospitalization their chance to develop PPC after abdominal surgery decreases. Therefore, the health-care staff has a very important role in this prevention.

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